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Bortnik V.A, professor Borovytsky V. M
Igor Sikorsky Kyiv Polytechnic Institute

EFFICIENCY OF CALIBRATION OF DISTORTION IN UAV VISION SYSTEMS

Annotation: The UAV vision system is used for various tasks, such as cartography, the construction of 3d object models, the creation of gigapixel shots, and for navigation. Many of these tasks require image stitching. An obstacle to high-quality image stitching is the presence of aberrations in the lens of the camera, especially the distortion. Therefore, elimination of this aberration will allow more accurately and with less computer expenses to perform the task of image stitchin.

Key words: UAV, image stitching, distortion calibration.

CAMERA MODELS

Digital image is 2D projection of scene of 3D world. Every point of 3D world can represent as matrix:

$$M = (X_0, Y_0, Z_0)^T \tag{1}$$

Also we can find corresponding projection on the homogeneous plane of this point:

$$m = (x, y)^T \tag{2}$$

The projection relationship between these points can represent as:

$$\lambda m = PM \tag{3}$$

where λ is scale matrix, P is 3x4 projection matrix, which can be expressed as:

$$P = K[RT] \tag{4}$$

where K is the intrinsic parameters matrix, R is a 3D rotation, T is a translation vector.

DISTORTION MODELS

Distortion is a deviation from rectilinear projection; a projection in which straight lines in a scene remain straight in an image. It is a form of optical aberration. Although distortion can be irregular or follow many patterns, the most commonly encountered distortions are radially symmetric, or approximately so, arising from the symmetry of a photographic lens. These radial distortions can usually be classified as either barrel distortions or pincushion distortions [1].

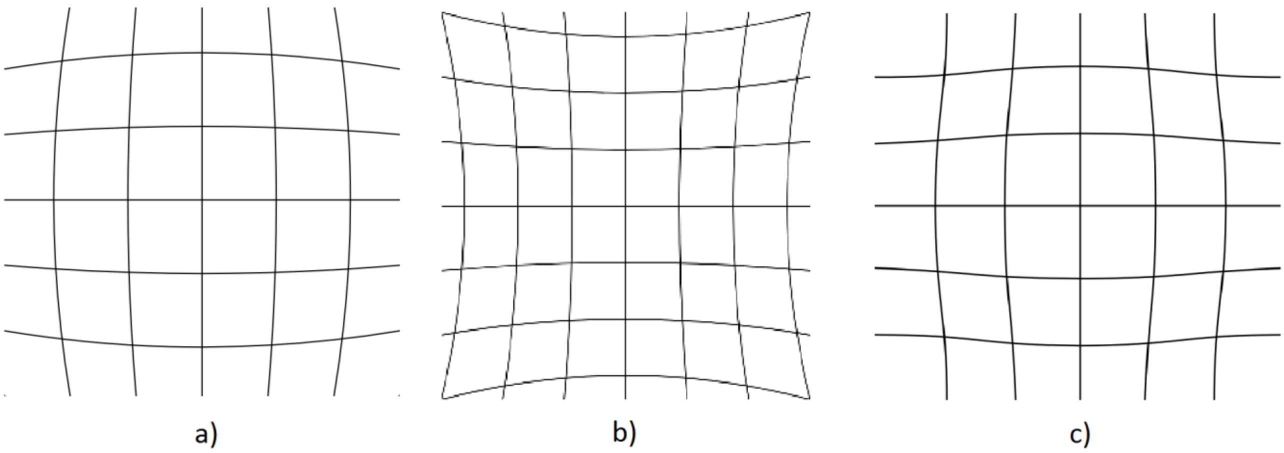

Figure 1. a) barrel distortion; б) pincushion distortion; в) mix of barrel and pincushion distortion.

If optical system has distortion matrix of point projection can represent as:

$$\mathrm{m}_d = (x_d, y_d)^T \tag{5}$$

where m_d is[2]:

$$\mathrm{m}_d = \begin{bmatrix} f(r)\cdot \mathrm{x} + 2\cdot k_3 \cdot x \cdot y + k_4(\mathrm{r}^2 + 2\cdot x^2) \\ f(r)\cdot \mathrm{x} + 2\cdot k_4 \cdot x \cdot y + k_3(\mathrm{r}^2 + 2\cdot y^2) \end{bmatrix} \tag{6}$$

where $f(r) = 1 + k_1 r^2 + k_2 r^4 + k_5 r^6$, and $r = \sqrt{x^2 + y^2}$, k_i is distortion coefficient.

DISTORTION CALIBRATION

In this section two methods of calibration of distortion were considered: on a periodic linear structure and concentric method.

PERIODIC LINEAR STRUCTURE

The calibration process on a periodic linear structure can be divided into four steps[3]:

1. Detection of points on curved line segments
2. Linkage of curved line segments
3. Outlier elimination
4. Final parameter estimation of the inverse radial distortion function

To begin with, it is assumed for the given that the direct 3D lines of space pass into the curve of the line on the image in the presence of distortion and remain straight in its correction. Correspondingly, for the beginning, find the points of the curve lines with the help of line detectors.

Since using short lines, the algorithm becomes sensitive to noise, it is necessary to use long lines and short throw away. It is also necessary to correctly determine the affiliation of individual points to one line, for this the distance between the points and the direction of each point in the line is analyzed. Also, the distance between the points of one line to the other is analyzed. As a result of filtration and communication, we obtain a set of lines, where each line is represented by a set of points.

Next it is necessary to determine the inverse function of distortion, on which the true image will be restored. To do this, select a random line from the set. Next, it is analyzed using the RANSAC method to exclude false inclusions of points. Then the reverse function of the distortion is calculated and applied to the given line. If we have found the correct function, then its application to all curves should give a straight line. To minimize the error, use the LM method. If for this line it was not possible to determine the correct function, then the next line from the set is taken and for it the function of distortion is invented. The procedure is repeated until a function is found that converts all curves from a set to a straight line.

At the end, minimization of the loss function for each parameter of the distortion function for each set of lines is performed.

CONCENTRIC CIRCLE METHOD

The second method involves the use of two concentric circles and a marker on the x-axis. This method described in [4]. First we need to restore the ellipses in the image. For example, using the computer vision library OpenCV we need find boundary using the Canny detector and after fit the ellipse.

As we get the 3D projection of the world, there is the possibility that the center of the ellipse in the image may not coincide with a real center. Therefore, we need to find the real center of two projecting ellipses, for example using [5].

Next, we need to restore the true position of these two circles using the marker on the x-axis. This can be done using the rotation and shift matrix.

Prior to this, it was assumed that the optical axis of the camera and the center of the circles coincided. Therefore, it is necessary to list the center of the ellipses given that the optical axis of the camera can be shifted. Then we can use the ellipse data to calculate the effect of distortion and its correction.

SUMMARY

In this paper the distortion model and methods of its calibration were considered. This allows you to get better image cross-links with low cost of computer facilities.

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Science Head-Doctor of Technical Sciences, Professor Borovitsky V.M.